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Nuclear Criticality Safety Evaluation for the Pantex Facility: Building 12-66 (U)

Westinghouse Savannah River Company
Criticality Safety Engineering

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October 1997

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Westinghouse Savannah River Company
Savannah River Site
Criticality Safety Engineering

September 30, 1997

To: Larry Skeen/Phil Stewart, Pantex Facility

From: Jack S. Bullington, 803-952-3385

Nuclear Criticality Safety Evaluation
for the Pantex Facility: Building 12-66 (U)

1) Introduction

A project is underway to upgrade the Pantex facility Building 12-66 to provide facilities to store approximately 12000 weapon pits in storage containers. The facility currently provides storage for miscellaneous and secondary components. As proposed, the central fire wall, sprinkler system and the racks currently used will be removed and new racks built to the required specifications. The old heating and ventilation system will be removed and a new system installed to provide adequate cooling such that thermally hot pits will not significantly degrade the celotex or fiberboard packing material in the AL-R8 containers. AL-R8 30 gallon containers loaded elsewhere with selected pits will be transferred to the Building 12-79 loading dock area, palletized into Stage Right pallets (4-packs or 6-packs), transferred to the airlock where the containers will be rotated to horizontal by the pallet turner and then into the vault for storage by the Automated Guided Vehicle. In some situations the loaded AL-R8 container will already be palletized prior to arrival at the Building 12-79 loading dock. Storage racks are to be built so that containers each containing one weapon pit can be stored in an array, nominally 90 containers long, 17 containers wide, and up to 9 containers high, and can be accessed through aisles by a Automated Guided Vehicle (AGV). Weapon pits will be contained in the AL-R8 container loaded per the AL-R8 Safety Analysis for Packaging (Reference 6). The AL-R8 container was at one time a DOT approved shipping package fully certified for over the road transport, but has since lost it's certification and can only be used for storage.

Per your request, I reviewed the available documentation and performed calculations to determine the adequacy of the facility for general storage of weapon pits in the AL-R8 Container.

This evaluation documents that all pits identified to be stored in Building 12-66 are acceptable for storage in the AL-R8 container in the proposed rack configuration.

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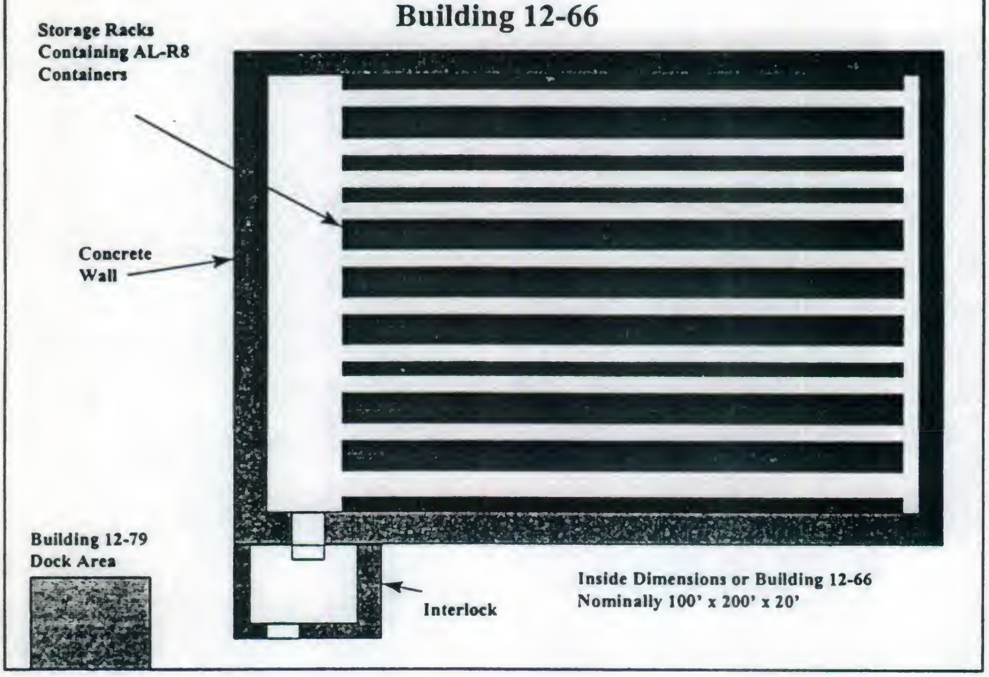
2) Description

Building 12-66

The Pantex facility Building 12-66 is a robust structure nominally 100 feet by 200 feet by 20 feet high with 1 foot thick concrete walls that will be modified for pit storage. The roof is tapered from 18 inches at the apex to 1 foot concrete on the sides. The structure is designed to withstand design basis accidents which makes it ideal for long term storage. Storage racks will be installed to contain pallets of 30 gallon containers using the Stage Right Concept. The current container design to be used is a Rocky Flats container AL-R8. The AT-400A container originally considered is not available at the time of this evaluation. The storage arrangement within Building 12-66 will consist of racks that support pallets of 6 or 4 containers (6-pack or 4-pack) laid on their sides, arranged up to three packs high, with a nominal 22 inch space between the second and third pallet in the same tier. Racks are separated by aisles for the AGV to transfer the pallets to their respective storage position. Some racks will be back-to-back.

Figure 1
Building 12-66



Building 12-79

The loading dock of the adjacent Building 12-79 will be used to receive loaded AL-R8 containers and assemble them into either packs of 4 or 6 containers on the Stage Right pallet. In some situations containers will already be assembled on the Stage Right pallet prior to arrival on the Building 12-79 Dock. The Building 12-79 loading dock and the Building 12-66 storage area are interconnected via an interlock. Once loaded, the pallets are turned on their side with a pallet turner and transferred through the interlock and into Building 12-66 with the AGV.

3) Requirements Documentation

This evaluation was prepared in accordance with the guidelines of the Westinghouse Savannah River Criticality Safety Manual (Reference 9), the WSRC Nuclear Criticality Safety Methods Manual (Reference 10) and additional guidance from the Pantex Plant Criticality Safety Program Analysis. Inherent in the requirements of these manuals is appropriate implementation of DOE Order 420.1 (formerly 5480.24) and ANSI/ANS-8 series national standards.

4) Methodology

Preliminary calculations were made using Hansen-Roach 16 group cross sections and the KENO V.a Monte Carlo Criticality Safety computer code on an IBM 3090 mainframe. HRXN is part of the Savannah River Technology Center Joshua (J70) System and KENO V.a is a well established criticality code associated with the SCALE (Reference 7) System. Subsequent calculations were made on a DGI Pentium 90 computer using the PC version of KENO V.a and KENO VI on a compact disc.

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The 27 group cross section library was used for all final calculations. Codes used are included in the Savannah River code validation and verification system. [redacted] To achieve the model detail desired an updated version of KENO VI was used. This version allowed nested arrays to allow container grouping to more closely represent the storage stall configuration. This code has limited validation and its results are provided for comparison and information purposes only.

HRXN and the 27 group library provide cross sections used in KENO. Mixtures used in this study are provided in Appendix A. KENO solves the three dimensional transport equation using statistically dependent Monte Carlo techniques and produces the system k-effective and confidence limits about the mean k-effective. The mean value of k-effective + 3 standard deviations (sigma) is required to be less than or equal to k-safe to maintain the safety margin. Typically, 150,000 to 270,000 neutron histories are adequate to produce a standard deviation of 0.002.

Biasing information was obtained from References 8 and 13. Reference 8 discusses fifty critical experiments with plutonium cores and average fission energies in the mid-range between thermal and fast to determine the bias and bias uncertainty for the 27 group ENDF/B-IV cross section libraries. These validation experiments for the plutonium/beryllium units all calculated criticality greater than unity and provided a lower tolerance (includes the bias uncertainty) band also greater than unity for the energy range of concern. Reference 13 identifies area of applicability (AOA) differences between single units and arrays as negligible. Normalizing the resulting biasing data to 1.0 results in a conservative upper bound k-effective (neutron multiplication factor) for this report of 0.95.

5) Discussion of Contingencies

To satisfy double contingency, the process must meet, as a minimum, ANS 8.1 sections 4.1.2 and 4.1.3, which require that the entire process be subcritical under both normal and credible abnormal conditions and that process operating procedures shall specify all parameters they are intended to control. This Double Contingency Analysis identifies the areas of concerns that may need resolution before the facility is actually operable.

Per discussions at the 26 August 1997 meeting at Pantex (Reference 11) ***this double contingency analysis will only identify the areas to be considered as required for the preliminary design report and will not provide the detail that would be normally provided in the final criticality safety evaluation/double contingency analysis.***

- Each of the nine parameters that are required to be controlled for criticality safety are listed in the Parameter column and a discussion of how it relates to the Building 12-66 facility is provided in the Discussion column.
- The Contingency column identifies a way or ways this parameter could fail but, may or may not be credible.
- The Barriers column identifies if the contingency is credible, based on engineering judgment or other means, and controls that must be in place if the contingency is identified as credible.

Pantex Plant practices defense in depth for the parameters controlled for criticality safety and is a step beyond parameter control. This typically drives the contingency to incredible or beyond extremely unlikely and is the reason Nuclear Incident Monitors are not used in the facility. The term "criticality concern" is used in the discussion section to simply identify a concern in which Pantex Risk Management would be notified and may or may not lead to a criticality scenario. The contingencies presented here are as they relate to Building 12-79 loading dock, the interlock between the loading dock and Building 12-66, and the Building 12-66 vault itself. Information relating to an airplane crash was extracted from Reference 12.

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Table 1			
Parameter	Barrier	Contingency	Discussion
Mass Control	This scenario is considered credible. Pits in AL-R8 storage containers are controlled by the Nuclear Material Control Center (NMCC) at Pantex and are tracked continuously. Written procedures specify which containers are to be placed in the vault.	A container with the incorrect identification containing a more reactive pit is sent to the vault.	Sending the incorrect container to the vault is a credible occurrence. Even though the tracking system is in place errors of this sort do occur. Pits will already be contained in approved storage containers by the time they arrive at the 12-79 dock.
	[redacted] Procedures specify the proper loading sequence for the AL-R8 container and require that a support frame be used for each pit. More than one pit supported by the frame can not physically fit in the container and not a credible scenario. The Nuclear Materials Control Center (NMCC) tracking system & security precludes handling more than one pit at a time.	More than one pit placed in a storage container or one pit placed incorrectly in container and stored in the vault.	Loading more than one pit in container would present an unstudied situation in the vault. Pits have been place upside down but that condition has no criticality safety consequence.
Mass Control Continued	Fissile material other than whole pits will not be staged in the vault. Pantex does not handle disassembled components, so this would have to be a shipment from another site. This is not a credible scenario because procedures are not in place to receive or transfer other containers or other fissile material to the vault. Receipt of just one of these containers into the vault would involve several procedural violations from several departments. Similarly, receipt of more than one or several unauthorized containers is also incredible.	Fissile material other than whole pits loaded in a storage container and taken to the vault.	Fissile material (from other sites) other than whole pits could potentially be sent to Pantex. This material stored in a 2030-1 (which is similar to an AL-R8) has not been studied for storage in the vault and would present an unanalyzed situation.
Moderation	The AL-R8 has a specific amount of celotex required at the time of loading to qualify as an AL-R8. Procedures specify the loading sequence of the celotex and the proper amount. For this to truly create a criticality problem the error would have to be repeated several times and go undetected. With the two person rule for handling fissile material repeating	Incorrect amount of celotex is placed in a container prior to loading with fissile material	Having less celotex than evaluated would negate this evaluation, increase fissile unit interaction (cross-talk) and present a criticality concern. However, since the AL-R8 container as modeled is mathematically reduced in size and quantity of celotex approximately 1/3 to account for triangular pitch some error is already evaluated.

Table II			
Parameter	Barrier	Contingency	Discussion
	the sequence over and over is considered to be incredible.		
	There are no sprinkler systems in Building 12-66 vault area and no other normal sources of moderation. Combustible material and ignition sources are limited in the vault. Fire crews are trained not to use fire hoses in the vault	Water is introduced into the vault in quantities significant enough to build an appreciable level in the vault	Water could be introduced into the vault for fire fighting purposes. A fire in the vault of sufficient magnitude could burn the celotex in the AL-R8 container and change the pit configuration. A fire of this magnitude would require an ignition source and then significant quantities of fuel to propagate beyond the incipient stage. This is unlikely since significant combustible materials are not allowed in the vault. The celotex in the AL-R8 provides a condition of near overmoderation. Therefore, for fires in the incipient stage, the addition of water would serve to isolate the pits and the vault reactivity would decrease and approach the reactivity of the single unit.
	None Identified	Airplane crash into the vault area	An airplane crash into the 12-66 or 12-79 facility in considered highly unlikely. The impact would cause extreme structural damage and release of radioactive material. Fire resulting from airplane fuel would char the celotex. Fire fighting activities would likely involve directing water streams into the storage area and potential localized flooding.
Geometry Control	Containers other than the AL-R8 container are not currently authorized for storage in the vault. Procedures identify the specific container to be used and only a 30 gallon container will fit in the Stage Right pallet.	A loaded container other than an AL-R8 is sent to the vault	The AL-R8 container is loaded with specific size and shape celotex and support frame. Changing this configuration would alter the basis of this evaluation and present an unstudied situation.
	This is considered an incredible event based on the current NMCC and security controls. Pits are already contained in approved storage containers by the time they arrive at the 12-79 dock. Containers will not be opened for any reason once they are at the 12-79 dock or in Building 12-66.	A bare pit is sent to the vault	A bare pit would present an unstudied scenario and would present a criticality concern.
Geometry Control Continued	Building 12-66 and the storage racks are seismically qualified to withstand a DBA. Reference to be added by Charles Hills.	Design Basis Accident (DBA)	During a DBA loaded AL-R8 containers could fall into the aisles, increase unit interaction and present a criticality concern.
	None identified	Airplane Crash	An airplane crash into the 12-66 or 12-79 facility in considered highly unlikely. The impact would potentially cause extreme structural damage, crush containers and release of radioactive material to the atmosphere.
Spacing	The only location that containers are handled individually is on the	A damaged container is sent to the vault or is damaged while in the	A damaged container could decrease the physical spacing between adjacent fissile units

Table 1			
Parameter	Barrier	Contingency	Discussion
	Building 12-79 loading dock. Containers are not stored individually in the vault outside of Stage Right Pallets. Procedures preclude storing a damaged container in the vault. Procedures also identify that if a container or a pallet is damaged or dropped while in the vault that it not be stored in the vault.	vault	and create a criticality concern. A single damaged container will not cause a criticality because the reactivity of a single unit is low. However, storage of that container in an array is not evaluated.
	A single loaded stage right pallet placed on the floor will not cause a criticality. This analysis evaluated many more containers in the vault than will actually be stored and the addition of more than one pallet will also not cause a criticality, but would definitely create a criticality concern. Procedures direct that undamaged containers are only stored in the storage racks. If a pallet is temporarily stored on the floor along the way, this pallet must be stored before another pallet is introduced to the vault.	Containers are stacked on the vault floor instead of in the racks.	If the AGV became inoperable along the way to a rack position and a six pack had to be placed on the floor, interim storage would be required. Additional storage on the floor outside of the racks is an unstudied scenario and presents a criticality concern. Containers containing certain pits are just subcritical or critical in infinite arrays. In either situation the margin of safety may be reduced. Therefore, the rack spacing is required for loaded containers.
	None Identified	Airplane Crash into the vault area	An airplane crash into the 12-66 or 12-79 facility in considered highly unlikely. The impact would cause extreme structural damage, crush containers and release of radioactive material to the atmosphere and change the spacing of the containers.
Density	No restriction on density. Plutonium was assumed as alpha phase plutonium at 19.82 g/cc and Uranium as 19.05 g/cc	Fissile material with higher density than evaluated is stored in the vault	Storage of pits at a plutonium or uranium density higher than that evaluated would present an unstudied situation. This is not likely since near theoretical density was assumed in the evaluation.
Absorption/ Reflection	No other absorbers or reflectors other than those specifically evaluated are allowed stored or staged interstitially to the vault area	Additional absorbers / reflectors added interstitially in the vault area. (excludes the AGV)	Only certain materials are evaluated in the vault area. Materials placed interstitially in the storage array (e.g., containers other than AL-R8s, steel sheets or drums of beryllium) may be safe but present an unstudied scenario.
Enrichment	No restriction on enrichment. Plutonium was assumed as 100% 239Pu; Uranium was assumed as 93.15% 235U. None of the pits evaluated for storage in 12-66 or even the B83 exceed the enrichment used in the evaluation.	Higher isotopic material than expected (studied) contained in an AL-R8 and placed in vault	Pits typically contain weapon grade plutonium (5. % to 6% 240Pu) and Uranium (93.15% 235U). The calculation performed in this analysis bound these enrichments.
Temperature	Heating and ventilation is provided in Building 12-66 to maintain a temperature around the	Pit temperature is sufficient to significantly degrade the celotex in AL-R8 containers	The celotex is important to the reactivity to the vault and its integrity must be maintained. Degraded celotex beyond the amount

Table 1

Parameter	Barrier	Contingency	Discussion
	pits such that the celotex does not degrade significantly and increase the interaction between the pits and increase vault reactivity		evaluated would present an unanalyzed situation.

6) Evaluation of Results

Table 2 was compiled to provide a comparison between all the pits scheduled to be stored in Building 12-66. The table provides:

- Unit ID
- Pit ID
- Design Agency (Los Alamos Nation Laboratory or Lawrence Livermore National Laboratory)
- Fissile plutonium and the form (delta or alpha)
-
- nominal outer dimensions

B-3

B-3

B.3

Preliminary/Generic Pit Calculations

The Building 12-66 storage array was modeled in its entirety. No credit was taken for any structural framework and containers were close packed along each row as well as reduced in size to account for triangular pitch. This model for the AL-R8 was extracted from the AL-R8 SARP and reduces diameter by approximately one-third. Seventeen individual arrays are considered along the width of the room with 10 aisles as indicated in the Preliminary Design Report. Each array is positioned 15 feet from the south end and 90 containers long. Each vertical tier is 9 containers high with a 22 inches dead space between the sixth and seventh container.

B.3

B-3

B-3

B-3 [redacted]

B-3 [redacted]

Specific Weapon Pit Calculations (References 1,2 3,4,5,12)

The next series of calculation involved modeling the specific weapon pits (Table 3) slated to be stored in building 12-66 using a grouping of pits from the original FL Shipping Container SARP. This grouping was provided verbally by the author of the FL Shipping Container SARP, Jerry Hicks, Rocky Flats, Safe Sites of Colorado and is provided below. Since the FL container is an approved package that has undergone extensive criticality safety review of the methodology used, it was considered acceptable to use the same methodology for this analysis.

Sample input files are provided in Appendix B and a sample output file is provided in Appendix C. Giff files that show the vault layout are provided in Appendix D.

B-3 [redacted]

B-3 [redacted]

B-3 [redacted]

[redacted] B-3

B-3 [redacted] investigates an intermediate spacing expansion of the array (half way between the close packed array and full expansion) along the length of the vault. The vault reactivity drops significantly as would be expected for increased neutron leakage. This version of KENO-VI did not model the nested arrays as desired and an updated version of KENO-VI was obtained from the code authors. B-3 [redacted] repeats the above calculation with a revised version of KENO-VI. This version has only limited validation and its results are provided only for comparison purposes.

B-3 [redacted] considers a full uniform spacing expansion along the length of the vault, representing the average nominal spacing between in the AL-R8 containers.

B-3 [redacted]

- considers the full expansion along the length of the vault
- takes credit for the fork lift tine slot in the back of the Stage Right pallet and [redacted] B-3
- adjusts the pit location in the drums in adjacent rows [redacted]

This is as close to the actual configuration that can be provided by this version of the KENO-VI and should suffice as the basis for this analysis.

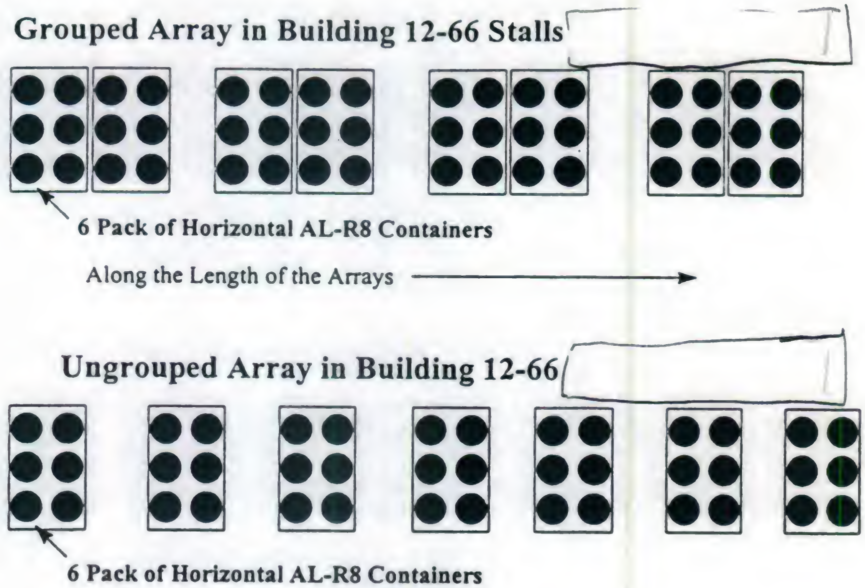

Figure 4

[redacted] considers the same array spacing as [redacted] except the Stage Right pallets are grouped into the storage stall configuration (two Stage Right pallets side by side) provided by the storage rack. The updated version of the KENO-VI code was required to perform this calculation with array within array capabilities.

[redacted] considers a 10 x 10 x 1 planar array [redacted] in AL-R8 containers in the vertical position with close concrete reflection on all sides except the ceiling. The ceiling is considered 14 feet high backed by 1 foot of concrete. The Building 12-79 loading dock is expected to receive up to 36 AL-R8 containers in one receipt. Even if two receipts were received this model is bounding.

Certainly, [redacted] is an accident scenario and having the entire vault filled or the loading dock filled with these is incredible. However, these examples do demonstrate that even for such an extreme situation criticality does not occur. [redacted] was originally obtained verbally from Charles Hills, Pantex Plant Risk Management, and later from [redacted]

B-3

B-3

Building 12-79 Loading Dock and Interlock

Up to 36 loaded Al-R8 containers will be placed in the Building 12-79 Loading Dock area dock and palletized into 4-packs and 6-packs prior to transfer into the interlock. This dock is not seismically qualified and could collapse during a design basis accident. Any containers on the dock could be crushed from falling I-beams and ceiling material. All pits in containers evaluated thus far are safe in infinite planar arrays( )and in a single calculation presented above (Table 5,) If a I-beam falls onto a planar array one would expect crushed containers and crushed or damaged pits directly under the beam and potential release of radioactive material. However, one would not expect a selective isolation of bare pits to a common location. One would also expect the array to be randomly oriented throughout the loading dock and certainly not oriented in a manner to produce a criticality. On the other hand if the containers are held in the Stage Right pallet and rotated so that one pit was positioned on top of the other in the pack, an I-Beam could crush one pit into another and produce an unanalyzed situation. This would suggest that containers on the loading dock should be:

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(b)(3)

- kept there as little time as needed to palletize and
- maintained in planar arrays and
- turned by the pallet turner only in the interlock.

The calculations presented earlier evaluated 13770 containers (Tables 4 and 5). This is significantly more than the 12440 containers that could be stored in Building 12-66. The introduction of 36 loaded containers to the Building 12-79 dock area will have negligible effect on the storage array provided the systems have been evaluated and approved for storage in Building 12-66.

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7) Design Features and Administratively Controlled Limits and Requirements
Design features of the facility include the following:

- The Building 12-66 facility is a robust facility designed to withstand a design basis accident (DBE, DBT).

- The AL-R8 containers were at one time certified for over the road transportation which means that they were subjected to the rigorous testing required for DOT certification. There is not a primary containment vessel in the AL-R8 which is one of the reasons the container lost certification.
- Pits in the AL-R8 container are supported only by the frame and the celotex. If the container is dropped and incurs significant damage, it should not be stored in the facility without further evaluation.
- The storage racks will be designed and fabricated to seismic qualifications to withstand a Design Basis Accident (DBE, DBT).
- The storage rack dimensions must be fabricated as described in the Preliminary Design Report and must be adhered to for this evaluation to be valid. The AL-R8 container packaging requirements must also be adhered to for this evaluation to be valid.

8) Summary and Conclusions

A nuclear Criticality Safety Evaluation was done for the Pantex Building 12-66 facility to determine if retired weapon pits could be safely stored in the proposed storage racks. Generic pits were evaluated initially for a preliminary acceptance determination for the vault. This was a very conservative look at close packed containers loaded [redacted] of plutonium/beryllium positioned in the seventeen arrays throughout the vault. The results provided confirmation that these [redacted] were acceptable for storage. Next, specific weapons pits scheduled to be stored in the vault were evaluated using the same conservative close packed container model as used earlier. Weapon pits currently scheduled to be stored in the facility include: w70, b28, w48, w56, b61-0,2,5, w68, w55, w71, w79, w44, w50, b57, w69, b43, b54, and w45. Calculations presented document that these are acceptable by a significant margin. Finally, an accident scenario of storing an incorrect pit in the vault was investigated. The pit selected is [redacted] the most reactive pit (in arrays) handled at the Pantex facility. [redacted] was substituted into the close packed array used in previous calculations and the reactivity increased beyond an acceptable limit. The arrays of containers were then expanded to more closely represent the storage configuration in the vault and k-effective decreased well below an acceptable limit of 0.95.

This evaluation documents that the proposed operation will be safe with a justified margin of safety of greater than 0.05. The pits acceptable for storage are listed in Table 2. Others could be stored after they are evaluated [redacted] The Double Contingency section, Section 5), indicates the necessary controls that Pantex Operations should implement prior to operation to ensure criticality control is maintained. However, this section provides a preliminary DCA to be used to identify areas of concern and should be repeated in greater detail prior to facility startup and operation.

9) References

1) T. P. Mclaughlin, ***Arrays of WR Systems of Los Alamos Origin***, March 14, 1994

Containers, October 14, 1980.

2) T. P. Mclaughlin, ***Transport Indices (for Criticality Control) for LASL Pits in AL-R8 Shipping Containers,*** October 14, 1980

3) O. C. Kolar and G. V. Pefley, ***Criticality Safety Memorandum No. 125, Criticality Safety of the W48 Weapon.*** February 3, 1969.

4) B. L. Koponen, ***Criticality Safety Memorandum No. 267, Rev. 1, Criticality Safety of the W79 Weapon***, March 3, 1977.

5) B. L. Koponen, ***Criticality Safety Memorandum No. 204, W70 Mock-up Shipment to Pantex***, January 25, 1972.

6) F. E. Adcock, RFE-8801, Revision October 1989, ***Rocky Flats Container, Model AL-R8 Safety Analysis Report for Packaging (SARP) (U).***

7) NUREG/CR-0200, Volumes 1,2,3, ORNL/NUREG/CSD-2; SCALE***: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluation***; December 1984

8) N-CLC-G-00065, ***SCALE 4.3 Validation - Plutonium Cores With Fast to Intermediate Fission Energies***; S. M. Revolinski, Westinghouse Savannah River Company, August 26, 1997.

9) WSRC-SCD-3, ***Westinghouse Savannah River Company Nuclear Criticality Safety Manual (U)***

10) WSRC-IM-96-33, ***Westinghouse Savannah River Company Nuclear Criticality Safety Methods Manual (U)***

11) Minutes, Joe Papp, ***Criticality Analysis for 12-66 Pit Staging Meeting, August 26, 1997***

12) DoE b(3)

13) N-CLC-G-0047, F. E. Trumble, ***SCALE Validation for WIPP;*** May, 1997.

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Appendix

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Appendix A: Mixtures and Compositions

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                         MIXING TABLE

              NUMBER OF SCATTERING ANGLES =  2
          CROSS SECTION MESSAGE THRESHOLD =3.0E-05


MIXTURE =      1   Plutonium Metal - Alpha Phase  DENSITY(G/CC) =  19.820
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT              NUCLIDE TITLE
   1094239  4.99299E-02  1.00000E+00   94239   239.0526       PLUTONIUM-239  ENDF/B-
IV MAT 1264                          UPDATED 08/12/94

MIXTURE =      2   Beryllium          DENSITY(G/CC) =  1.8480
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT              NUCLIDE TITLE
   2004009  1.23487E-01  1.00000E+00    4009     9.0124       BERYLLIUM-9    ENDF/B-
IV MAT 1289/THRM1064                 UPDATED 08/12/94

MIXTURE =      3   Carbon Steel       DENSITY(G/CC) =  7.8212
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT              NUCLIDE TITLE
   3006012  3.92503E-03  1.00001E-02    6000    12.0001       CARBON-12      ENDF/B-
IV MAT 1274/THRM1065                 UPDATED 08/12/94
   3026000  8.34982E-02  9.90000E-01   26000    55.8447       IRON           ENDF/B-
IV MAT 1192                          UPDATED 08/12/94

MIXTURE =      4   Celotex            DENSITY(G/CC) = 0.19986
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT              NUCLIDE TITLE
   4001001  7.42820E-03  6.21900E-02    1001     1.0077       HYDROGEN       ENDF/B-
IV MAT 1269/THRM1002                 UPDATED 08/12/94
   4006012  4.45690E-03  4.44367E-01    6000    12.0001       CARBON-12      ENDF/B-
IV MAT 1274/THRM1065                 UPDATED 08/12/94
   4008016  3.71410E-03  4.93443E-01    8016    15.9904       OXYGEN-16      ENDF/B-
IV MAT 1276                          UPDATED 08/12/94

MIXTURE =      5   Regular Concrete   DENSITY(G/CC) =  2.3000
   NUCLIDE   ATOM-DENS.   WGT. FRAC.      ZA      AWT              NUCLIDE TITLE
   5001001  1.37437E-02  9.99867E-03    1001     1.0077       HYDROGEN       ENDF/B-
IV MAT 1269/THRM1002                 UPDATED 08/12/94
   5008016  4.60814E-02  5.31997E-01    8016    15.9904       OXYGEN-16      ENDF/B-
IV MAT 1276                          UPDATED 08/12/94
   5011023  1.74722E-03  2.90003E-02   11023    22.9895       SODIUM-23      ENDF/B-
IV MAT 1156                          UPDATED 08/12/94
   5013027  1.74537E-03  3.40003E-02   13027    26.9818      AL-27 1193 218 GP
040375(5)                                  UPDATED 08/12/94
   5014000  1.66199E-02  3.37003E-01   14000    28.0853       SILICON        ENDF/B-
IV MAT 1194                          UPDATED 08/12/94
   5020000  1.52055E-03  4.40004E-02   20000    40.0803      CALCIUM ENDF/B-IV MAT
1195                                  UPDATED 08/12/94
   5026000  3.47236E-04  1.40001E-02   26000    55.8447       IRON           ENDF/B-
IV MAT 1192                          UPDATED 08/12/94
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MIXTURE =      6   Aluminum        DENSITY(G/CC) =  2.7000
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
   6013027  6.02620E-02  1.00000E+00   13027    26.9818     AL-27 1193 218 GP
040375(5)                              UPDATED 08/12/94

MIXTURE =      7   High Enriched Uranium  DENSITY(G/CC) =  19.050
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
   7092235  4.54652E-02  9.31500E-01   92235   235.0441      URANIUM-235    ENDF/B-
IV MAT 1261                         UPDATED 08/12/94
   7092238  3.30116E-03  6.85000E-02   92238   238.0510      URANIUM-238    ENDF/B-
IV MAT 1262                         UPDATED 08/12/94

MIXTURE =      8   Depleted Uranium       DENSITY(G/CC) =  19.050
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
   8092235  9.76148E-05  1.99995E-03   92235   235.0441      URANIUM-235    ENDF/B-
IV MAT 1261                         UPDATED 08/12/94
   8092238  4.80957E-02  9.98000E-01   92238   238.0510      URANIUM-238    ENDF/B-
IV MAT 1262                         UPDATED 08/12/94

MIXTURE =      9   Stainless Steel 316    DENSITY(G/CC) =  7.7500
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
   9006012  3.11144E-04  8.00005E-04    6000    12.0001      CARBON-12      ENDF/B-
IV MAT 1274/THRM1065                UPDATED 08/12/94
   9014000  1.66178E-03  9.99998E-03   14000    28.0853      SILICON        ENDF/B-
IV MAT 1194                         UPDATED 08/12/94
   9024000  1.52593E-02  1.70000E-01   24000    51.9957     CR 1191 218NGP WT 1/E P-
3 293K SIGP=5+4 RE(042375)        UPDATED 08/12/94
   9025055  1.69906E-03  1.99999E-02   25055    54.9379      MANGANESE-55   ENDF/B-
IV MAT 1197                         UPDATED 08/12/94
   9026000  5.46740E-02  6.54200E-01   26000    55.8447      IRON           ENDF/B-
IV MAT 1192                         UPDATED 08/12/94
   9028000  9.54318E-03  1.20001E-01   28000    58.6872     NI 1190 218NGP WT 1/E P-
3 293K SIGP=5+4 RE(042375)        UPDATED 08/12/94
   9042000  1.21616E-03  2.50000E-02   42000    95.9402     MO (1287) SIGP=5+4
NEWXLACS 218NGP F-1/E-M P-3 293K     UPDATED 08/12/94

MIXTURE =     10   Vanadium        DENSITY(G/CC) =  5.9600
   NUCLIDE   ATOM-DENS.   WGT. FRAC.     ZA       AWT                NUCLIDE TITLE
  10023051  7.04570E-02  1.00000E+00   23051    50.9416     V 1196 218 GP 1/E*SIGT
040375(5)                           UPDATED 08/12/94
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Appendix B
Sample Input Files

Input file vw70.in

B-3

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Input file b83pm.in

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25 of 206

What is on P. 25?

Should *probably* be redacted.

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